

# Industry 5.0

The Future of the  
Industrial Economy

Uthayan Elangovan



CRC Press  
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**CRC Press**

Taylor & Francis Group

Boca Raton London New York

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CRC Press is an imprint of the  
Taylor & Francis Group, an **informa** business

First edition published 2022

by CRC Press

6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742

and by CRC Press

2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

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CRC Press is an imprint of Taylor & Francis Group, LLC

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*Library of Congress Cataloging-in-Publication Data*

Names: Elangovan, Uthayan, author.

Title: Industry 5.0 : the future of the industrial economy / Uthayan Elangovan.

Description: First edition. | Boca Raton : CRC Press, 2022. |

Includes bibliographical references and index.

Identifiers: LCCN 2021028869 (print) | LCCN 20210288702 (ebook) |

ISBN 9781032041278 (hardback) | ISBN 9781032041285 (paperback) | ISBN 9781003190677 (ebook)

Subjects: LCSH: Industry 4.0. | Society 5.0. | Automation. | Robots, Industrial. | Human-computer interaction. | Industrial engineering. | Internet of things—Industrial applications. | Artificial intelligence—Industrial applications. | Manufacturing industries—Technological innovations.

Classification: LCC T59.6 .E43 2022 (print) |

LCC T59.6 (ebook) | DDC 658.4/0380285574—dc23/eng/20211103

LC record available at <https://lcn.loc.gov/2021028869>

LC ebook record available at <https://lcn.loc.gov/2021028870>

ISBN: 978-1-032-04127-8 (hbk)

ISBN: 978-1-032-04128-5 (pbk)

ISBN: 978-1-003-19067-7 (ebk)

DOI: 10.1201/9781003190677

Typeset in Times

by codeMantra

# *Dedication*

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*To my parents, Elangovan Rajakani and Kanmani  
Elangovan, who educated me on the qualities of self-control  
over and above honors of education and learning*



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# Preface

The rate of modern technology creation and fostering certainly varies across different industrial sectors. Technology is frequently progressing, and production must develop with it to stay competitive. While Industry 4.0 is still the primary transformation for many manufacturing leaders, it's crucial to look toward the future. In the industrial sector, the Internet of Things represents an effective modern technology driving a lot of the modifications since the introduction of the Industrial Internet of Things, providing significant benefits to manufacturers from different industries. This publication endeavors to provide a glimpse of how small to medium enterprises and original equipment manufacturers can best leverage, increasing the process effectivity, operational effectivity, reducing unskilled workforce utilizing Industry 3.0 to Industry 4.0 through Industry 5.0, will definitely lead to the manufacturing of greater worth tasks than ever before, driving optimum outcomes from human-to-machine interactions.

I have always had a passion for advancement in product lifecycle management and computer-integrated manufacturing. Being a PLM and IIoT business consultant, I've had opportunities to assist manufacturing enterprises to enhance their business processes, finding methods to fix issues and help them start off their transformation journey. I feel obliged to share my knowledge along with my experience. I hope that the information and expertise offered here will awaken business leaders, product design and development professionals, manufacturers, industrial automation professionals, IT professionals, consultants, and academies to come to the realization that to improve engineering process, they need production effectivity, quality, and zero waste manufacturing ecosystem.

I wish you enjoy your reading.



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# Acknowledgments

I would certainly like to express my gratitude to several individuals who saw me through this book; to all those who offered assistance, talked things over. Thanks to Cindy Renee Carelli – Executive Editor, Erin Harris – Senior Editorial Assistant, my publisher CRC Press/Taylor & Francis Group: without you, this book would certainly never find its place in the digital world, and to a lot of individuals throughout this global village.

I thank Joel Stein for revealing the course to authoring this book.

I would like to thank my friends – Subject Matter Experts, who took part in the design thinking process – S. Palanivel, E. Srinivas Phani Chandra, A. Babu, K. Manikannan, V. Venkataramanan, V. Bhuvaneshwaran, D. Gopinath, K. Gopinath, R. Selvaraj, E. Kamalanathan, N. Ganesh, S. Rajaprakash, P. Saravanan, A. Kalidhas, and P. Baskar.

I express my love and gratitude to my parents, my wife – Saranya Uthayan, my son – U. Neelmadhav, my professors, my good friends, associates in the business, and all my well-wishers, without whom this book would not have been possible.



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# Author

**Uthayan Elangovan** has 17 years of dynamic experience, ranging from product life-cycle management (PLM) to Industrial Internet of Things (IIoT) consulting for an assortment of businesses, including automotive, electrical, medical, industrial, and electronics enterprises. He helps and leads PLM, IIoT usage, and subventures, and with cutting-edge collaboration tools and techniques, he gives consultations to worldwide clients. Energetic about PLM, IIoT, and its effect on product development guaranteeing PLM, IIoT system meets client deliverables while supporting business processes. His interest in making technological advancements in automation influenced him to write his first book *Smart Automation to Smart Manufacturing – Industrial Internet of Things*, which was named as one of the Best Manufacturing Automation books of all time by Book Authority. His passion for PLM and IIoT influenced him to author his second publication *Product Lifecycle Management (PLM): A Digital Journey Using Industrial Internet of Things (IIoT)*, which was named as one of the Best Industrial Management books of all time, New Industrial Management books to be read in 2021 and New Product Design books to be read in 2021 by BookAuthority.

He earned a bachelor's degree in mechanical engineering from Kongu Engineering College and a master's degree in computer-integrated manufacturing from PSG College of Technology. He currently resides in Tamil Nadu, India, and is a consultant for PLM and IIoT, providing business and education consulting through his firm – Neel SMARTEC Consulting.





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# Abbreviations

<b>ADAS</b>	Advanced Driver Assistance System
<b>AGV</b>	Automated Guided Vehicle
<b>AI</b>	Artificial Intelligence
<b>AM</b>	Additive Manufacturing
<b>AMS</b>	Aerospace Materials Specifications
<b>APC</b>	Advanced Process Control
<b>APQP</b>	Advanced Product Quality Planning
<b>AR</b>	Augmented Reality
<b>ASPICE</b>	Automotive Software Performance Improvement and Capability dEtermination
<b>BOM</b>	Bill of Material
<b>BPA</b>	Bisphenol A
<b>BPM</b>	Business Process Management
<b>CAD</b>	Computer-Aided Design / Drafting
<b>CAE</b>	Computer-Aided Engineering
<b>CAM</b>	Computer-Aided Manufacturing
<b>CAPA</b>	Corrective Action Preventive Action
<b>Cax</b>	Computer-Aided technologies
<b>CFD</b>	Computational Fluid Dynamics
<b>CFT</b>	Cross-Functional Team
<b>CIM</b>	Computer-Integrated Manufacturing
<b>CNC</b>	Computer Numerical Control
<b>CRM</b>	Customer Relationship Management
<b>CTQ</b>	Critical to Quality
<b>CQI</b>	Continuous Quality Improvement
<b>DL</b>	Deep Learning
<b>DCS</b>	Distributed Control System
<b>DFA</b>	Design for Assembly
<b>DFB</b>	Design for Fabrication
<b>DFE</b>	Design for Environment
<b>DFM</b>	Design for Manufacturing/Design for Manufacturability
<b>DFMEA</b>	Design Failure Mode and Effect Analysis
<b>DFR</b>	Design for Reliability
<b>DFT</b>	Design for Testing
<b>DFSC</b>	Design for Supply Chain
<b>DFSS</b>	Design for Six Sigma
<b>DFx</b>	Design for Excellence
<b>DPA</b>	Digital Process Automation
<b>DMAIC</b>	Define, Measure, Analyze, Improve, and Control
<b>DMT</b>	Defect Mapping Tool
<b>DOE</b>	Design of Experiments
<b>DRC</b>	Design Rule Checks

<b>EaaS</b>	Energy-as-a-Service
<b>eBOM</b>	Engineering Bill of Material
<b>ECAD</b>	Electronic Computer-Aided Design
<b>EDA</b>	Electronic Design Automation
<b>EMS</b>	Electronic Manufacturing Service
<b>Ems</b>	Environment Management System
<b>ERP</b>	Enterprise Resource Planning
<b>ESD</b>	Electrostatic Discharge
<b>ESG</b>	Environmental, Social, and Corporate Governance
<b>FMEA</b>	Failure Mode and Effects Analysis
<b>FEA</b>	Finite Element Analysis
<b>FEM</b>	Finite Element Method
<b>FDA</b>	Food and Drug Administration
<b>GRN</b>	Goods Receipt Note
<b>GPU</b>	Ground Power Units
<b>GSE</b>	Ground Support Equipment
<b>HMI</b>	Human–Machine Interface
<b>IATF</b>	International Automotive Task Force
<b>ICS</b>	Industrial Control System
<b>ICT</b>	Information and Communication Technology
<b>IDOV</b>	Identify, Design, Optimize, and Verify
<b>IEC</b>	International Electrotechnical Commission
<b>IIoT</b>	Industrial Internet of Things
<b>IoT</b>	Internet of Things
<b>IPA</b>	Intelligent Process Automation
<b>IPC</b>	Institute of Printed Circuits
<b>IR</b>	Infra-Red
<b>ISO</b>	International Organization for Standardization
<b>IT</b>	Information Technology
<b>JIT</b>	Just-In-Time
<b>KPI</b>	Key Performance Indicator
<b>M2M</b>	Machine 2 Machine
<b>ML</b>	Machine Learning
<b>MES</b>	Manufacturing Execution System
<b>MSA</b>	Measurement System Analysis
<b>MDM</b>	Medical Device Manufacturer
<b>MRO</b>	Maintenance, Repair, and Overhaul
<b>MRP</b>	Material Requirements Planning
<b>MSD</b>	Moisture-Sensitive Device
<b>MVDA</b>	Multivariate data analysis
<b>MVP</b>	Minimum Viable Product
<b>NC</b>	Numerically Controlled
<b>NLP</b>	Natural Language Processing
<b>NPD</b>	New Product Development
<b>NPI</b>	New Product Introduction
<b>OEE</b>	Overall Equipment Effectiveness

<b>ODM</b>	Original Design Manufacturer
<b>OEM</b>	Original Equipment Manufacturer
<b>OCR</b>	Optical Character Recognition
<b>PCB</b>	Printed Circuit Board
<b>PCA</b>	Printed Circuit Assembly
<b>PCBA</b>	Printed Circuit Board Assembly
<b>PCA</b>	Process Control Automation
<b>PCS</b>	Process Control System
<b>PDM</b>	Product Data Management
<b>PEEK</b>	PolyEther Ether Ketone
<b>PESTLE</b>	Political, Economic, Social, Technological, Legal, and Environmental factors
<b>PLC</b>	Programmable Logic Controller
<b>PLM</b>	Product Lifecycle Management
<b>PMEA</b>	Process Failure Mode and Effects Analysis
<b>PPAP</b>	Production Part Approval Process
<b>PVC</b>	Polyvinyl Chloride
<b>QFD</b>	Quality Function Deployment
<b>QMS</b>	Quality Management System
<b>RCA</b>	Root-Cause Analysis
<b>RF</b>	Radio-Frequency
<b>RFID</b>	Radio-Frequency Identification
<b>ROI</b>	Return of Investment
<b>ROV</b>	Return of Value
<b>RPA</b>	Robotic Process Automation
<b>RPN</b>	Risk Priority Number
<b>SCADA</b>	Supervisory Control and Data Acquisition
<b>SCARA</b>	Selective Compliance Assembly Robot Arm
<b>SCM</b>	Supply Chain Management
<b>SME</b>	Small to Medium Enterprise
<b>SMT</b>	Surface Mount Technology
<b>Solar PV</b>	Solar PhotoVoltaic
<b>SPC</b>	Statistical Process Control
<b>SWOT</b>	Strengths, Weaknesses, Opportunities, and Threats
<b>THT</b>	Through Hole Technology
<b>TPS</b>	Toyota Production System
<b>TCP/IP</b>	Transmission Control Protocol/Internet Protocol
<b>VPVC</b>	Unplasticized Polyvinyl Chloride
<b>VSM</b>	Value Stream Mapping
<b>VR</b>	Virtual Reality
<b>WCM</b>	World Class Manufacturing
<b>WEEE</b>	Waste Electrical and Electronic Equipment



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# 1 Industrial Transformation

Manufacturing industries around the global village are on the threshold of great opportunities that promise extraordinary development and transformation of their business through smart products and smart manufacturing, enabled by cutting-edge technological innovation. Industrial sectors sell their products through complex processes such as research, design, development, manufacturing and service. Every product manufacturing segment has unique challenges that cannot be tackled by a one solution that fits all requirements. Manufacturing enterprises perennially encourage the development of science and technology and adopt a variety of approaches to transform their businesses, thereby constantly seeking new ways to upgrade and distinguish themselves from their competitors.

Digitalization has heralded a new paradigm in manufacturing, where manufacturing facilities are transformed to be extra modern and advanced. Consequently, this arouses concerns in the minds of business tycoons: will the emerging technologies take control of the manufacturing production line of futuristic factories? In a world of burgeoning modern technology, many manufacturers stand to gain much from automation, if the circumstances are exploited right. Taking automation to the next level can be a huge advantage for the manufacturing industry. Advanced automation can help reduce a holdup, reduce production expenses and enhance product quality.

Industrial sectors are reshaping their competitive landscape and steering in to a new era of growth, change and economic opportunity. Every organization requires their employees and machinery to do their jobs with greater efficacy and proficiency while managing operations, designing products as well as establishing intellectual property throughout the globe. The ultimate objective of industrial transformation is to achieve a better quality of product and service for the customer. Current business systems, including computer-integrated manufacturing (CIM), product lifecycle management (PLM), enterprise resource planning (ERP), manufacturing execution systems (MES), programmable logic control (PLC) and supervisory control and data acquisition (SCADA) along with Industrial Internet of Things (IIoT), are now being utilized to ensure that a superior user experience, quick time to value, integration of information and easy access from anywhere across the globe are realized. Innovation is making an impact on every stage action from product design to manufacturing.

Today, manufacturing industries are developing techniques for combining new innovations to improve their efficacy and performance, the leading concept behind Industry 4.0. It is essential to closely assess the elements of the business, from client connections to reshoring options and likely a lot more. Robotics has emerged to become the mainstay in production, and, Industry 4.0 innovations offer greater versatility in manufacturing processes. Manufacturers can also introduce new automation and artificial intelligence-assisted effectiveness to their enterprises. Heralding the next industrial transformation calls for the adoption, standardization and execution of new technologies, which requires its very own framework as well as advancements.



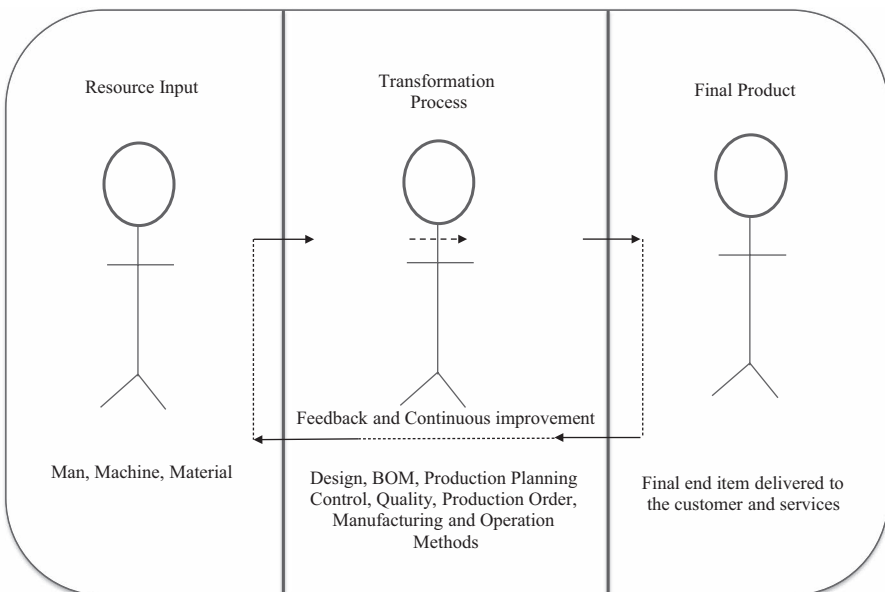
## BUSINESS TRANSFORMATION

Business transformation is a strategic initiative on every business leader’s campaign to remain competitive, which consists of workers, processes, as well as innovation to achieve measurable enhancements in effectiveness, performance and complete customer satisfaction. Organizations that continuously adapt are driven by a keen vision to redesign their future via transformation. An improvement is a major change in an organization’s abilities and identity to ensure that it can deliver valuable outcomes, pertinent to its objective, which it could not accomplish previously. Business transformation is more defined by a high level of passion of the organization as a substantial space that should be linked in between the current and future enterprise path. It represents an essential enhancement in the present business operations. A robust commitment to value expansion is an effective directive for identifying the efforts that will certainly have the best influence on an enterprise transformation road map and also for understanding its prospective worth for investors.

Among the successful business change instances is Apple – from being a producer of computer systems, Apple has slowly taken place to customer devices. Experts say the shift has been smooth. After the launch of iPod, Apple changed from being a hardware and software supplier, to the domain of customer electronic devices. With the launch of iTunes Music store, Apple became a media business.

*(Gupta and Perepu 2006)*

Service improvement needs to consistently be a step in the right direction for a thriving business. Because of this, business transformations need to aim at making inroads in to entering a brand-new section of the marketplace, adding industrial value to the business, improving the efficacy of the manufacturing processes and making best use



**FIGURE 1.1** Simple transformation process.

of the available resources. Business advancement aspects differ for every manufacturing enterprise. This is because every enterprise has their own strength to leverage and difficulties to deal with. The path toward business transformation is never easy, as it is fraught with challenges. Irrespective of the nature as well as the objective of the transformation, all enterprises can anticipate significant resistance to change. For a successful transformation, the management must dare to take risks and must be steadfast and meticulous in its execution. The success of a business transformation squarely built on the ability of the enterprise to adapt to change in strategies often determined by market change, disruptive needs and tactical direction. The ability of the management to overcome these obstacles is one of these the crucial success variables.

## **KEY ELEMENTS OF BUSINESS TRANSFORMATION**

Manufacturing industries need to direct their attention from mere survival to seeking new methods to grow. Considering globalization and the fast pace of today's business, there are no quick fixes for simplifying business intricacies. Globalization has made it hard to keep organizational frameworks simple. Today's multinational businesses have thousands of employees, numerous organization companions and substantial operations spread across the globe. Following an appropriate enterprise organization structure and also operating model is an ongoing battle.

Few questions that can help manufacturing industries to understand the need for business transformation are as follows:

1. How pleased are the clients with your product and service?
2. What are the different ways to enhance client experience?
3. How to prosper in the current smart and connected competitive world?
4. How would certainly financial investments in technology improve the experience?
5. How can success be determined?

Manufacturing industries cannot transform successfully unless their individuals within the enterprise transform; majority of the transforming initiatives fail because enterprise overemphasizes the tangible side of the transformation. Business transformations within an enterprise impact the monitoring of operational settings, interfere with the cultural norms, modify service procedures and capitalize on new modern technologies. Some examples of business transformations in industrial sectors are as follows: organization transformation, technology transformation, business process transformation and industrial transformation.

## **ORGANIZATION TRANSFORMATION**

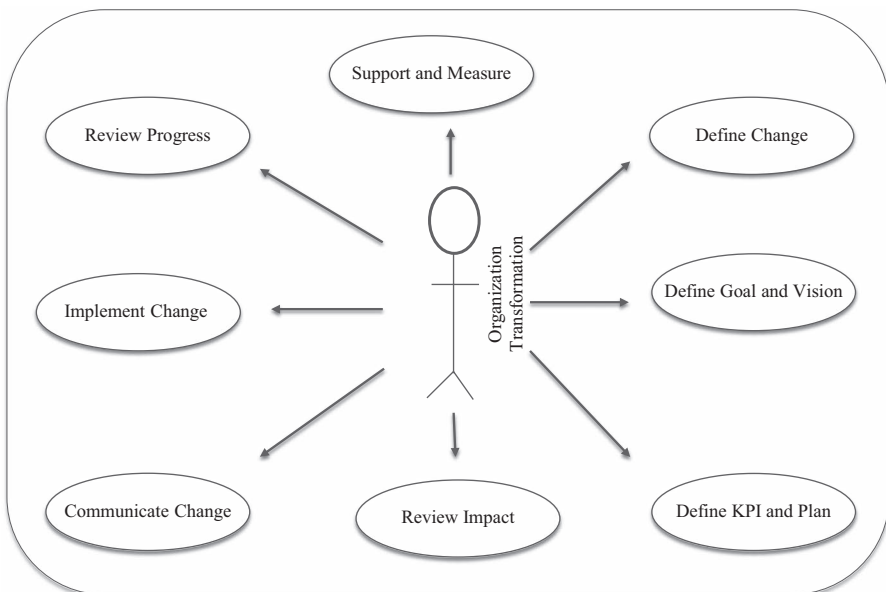
Organization transformation is a basic, enterprise-wide change impacting how a company is run while focusing on augmenting its efficiency and proficiency. Organization transformation is a term that refers collectively to activities such as reengineering, revamping and redefining organization systems, and it happens in response to rapidly changing demands and the compulsive need to improve the enterprise's efficiency along with sustainability. It shows the measures adopted by the business leaders

to steer the business successfully into the future and to achieve the desired result. However, if the company perceives delays in its quarterly reports, it might have a much more substantial issue on its hands. As every business experiences cycles of development along with change, this is an opportunity to analyze the performance of the company and prepare a strategic plan for its future. What is required is an alternative procedure that companies can utilize to help them incorporate as well as implement changes throughout the organization.

Google achieved organization transformation by developing higher division. Research and development division dealt with such a variety of projects that it was ending up being tough for management executives to concentrate on innovation. Tactical solution devised is splitting right into several business entity, each of them with a slim focus, responding to the new parent firm Alphabet.

*Alphabet Inc. (2017)*

Maintaining a keen eye on both the problems will provide an insight into whether or not any organization transformation is needed. Change is usually driven by C-level executives who are in charge of process of the organization. It is important for the success of any transformation program that the organization rightly identifies the reality and is prepared to adopt the required procedures without losing focus as the organization transformation initiative is implemented. Transforming an organization requires the ability to be agile, receptive to market trends and technology, whenever essential. These adjustments are lasting only when they affect the end users to alter their actions and influence supervisors to adapt and approve brand-new concerns. Organization transformation is more likely to do well when the organization agrees to accept the change and when the scheduled modification is integrated well with existing business control systems and also culture. Transformational changes call for



**FIGURE 1.2** Organization transformation.

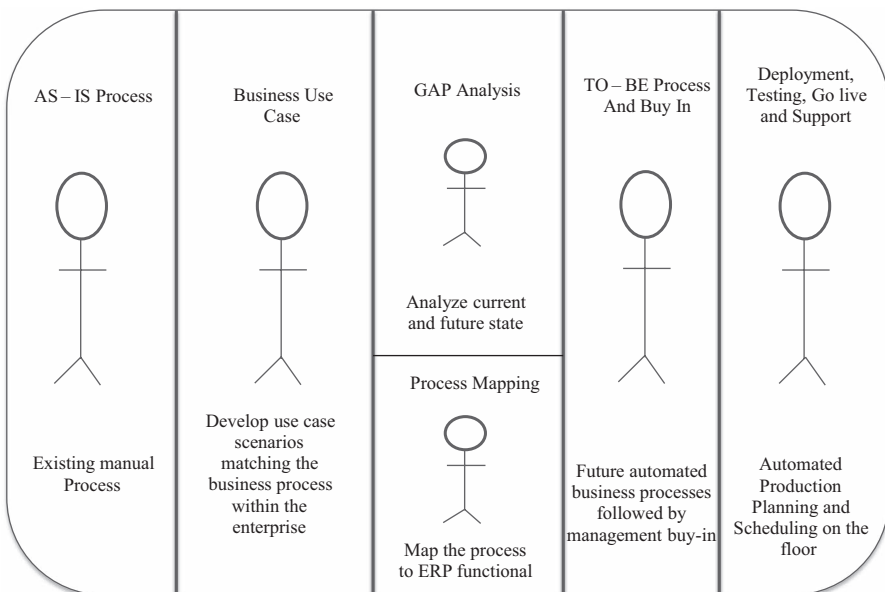
considerable advancement besides learning. Business participants need to discover exactly how to enact the new ways and carry out new approaches. Regardless of the level of the organizational transformation, it is critical that the organizational effect and threat analyses are carried out to permit C-level executives to recognize the resources necessary to efficiently execute the modification effort and to establish the impact of the modification on the organization.

**BUSINESS PROCESS TRANSFORMATION**

Business process transformation is the essential rethinking of a process within an enterprise. This focusses on the end-to-end placement of the main purposes, measures, information, metrics and innovation in accordance with the strategic goals and also the tactical needs of the business, delivering a significant, calculated increase in client value. It entails an assessment of the actions called for to attain a specific objective in an effort to remove replicate process tasks. Identifying a process will aid in saving time, speed up the return on investment and return on value and save sources. It is essential to recognize the best alternatives in order to pick the best technology and application plan to sustain both business process transformation needs and strategic goals. Primarily, business process transformation is driven by market needs and entails automating as many procedures as possible.

“Siemens Vision 2020, which outlined an organizational overhaul, restructuring, and also calculated shift from energy and also commercial manufacturing to digitalization.” “Philips Split its lights core from its medical care growth company, changing itself into a health care modern technology firm.”

*(Anthony et al., 2019)*



**FIGURE 1.3** Business process transformation – ERP implementation.

Business process transformation is a deliberate and organized extension of the transformation journey that garners a substantial return on investment leading to breakthroughs in an organization's efficiency outcomes. Whatever the target or nature of the business change, the goal is always to reinforce its relevance in the competitive market in order to guarantee its survival. Thus, business process transformation is a beneficial goal and a vital building block for any significant and calculated changes made within the enterprise. It is arguably a crucial action in every kind of service modification. During the COVID-19 pandemic, several transformational fads were set to speed up, swiftly. Many companies in different industrial sectors were under tremendous stress to quickly adapt their service designs in this radically altered market conditions in order to stay successful. The most significant risk to any effective business process transformation is aligning it with a suboptimal data method. Like organization transformation, business process transformation too requires cautious planning, clear objectives and confident administration.

## **TECHNOLOGY TRANSFORMATION**

Technology transformation is a vital part of competitive business practices today in this smart connected world. Most of the industrial application systems used in the enterprise are attracted by new cutting-edge technological advancements by innovative companies with response to expectations of customers. These enterprises are consistently evolving their internal information technology ecosystem to minimize hazards and simultaneously boost business continuity. Industry 4.0 is currently sweeping the industrial economic scene in a manner similar to the impact of the mass media and communications on the industry over the past decade.

Innovation in every industrial sector supports the creation of all new, digitally enabled business models, while holding out the important assurance of boosting consumer experiences and enhancing the productivity of legacy process. The information and communications technology revolution is transforming conventional sectors, ensuing changes and big modifications in well-established ecosystems. Advanced innovations are vital to modern business, and, it is fair to claim that every big manufacturing sector needs to move toward this transformation to attain growth. Technologies transformed the method individuals functioned, but they did not fundamentally alter the way businesses ran. Certainly, technological innovation can itself be a driver for massive organizational changes such as the method by which employees interact with each other and the manner in which the business engages with customers, companions and also various other stakeholders engage. The COVID-19 pandemic has augmented the demand for driving technological transformation across businesses of all dimensions. Enterprises are welcoming remote jobs and swiftly customizing their daily procedures to match the new normal.

## **INDUSTRIAL TRANSFORMATION**

Industrial sectors are continuously growing and transforming by seeking essentially new methods to enhance monetary assets besides functional performance, safety and security, high quality and competitive advantage. One of the main developments is the

exchange of information between during various stages of the customer service. Industry leaders often challenge their internal groups to come up with the most effective and innovative ways to transform their businesses utilizing digital innovations, improving value chain processes and through collaborative work environment to serve the markets better. An effective industrial transformation requires not only innovation but also a shift in the perspectives of the people who eventually apply and also utilize the new processes.

## **TRANSFORMATION IN INDUSTRIAL MANUFACTURING**

Technology is omnipresent and continues to transform numerous sectors particularly the production market. Business enterprises need to continually update on technical development, if the industries have to remain competitive, which implies that manufacturing services need to be aware of what is the best and also the most recent innovation. Innovative methods are adopted in the process of selecting the material and made use of in the manufacturing process; this has made the process less labor-intensive and much safer, consequently boosting the operation. The use of computers and smart devices each day has actually boosted the performance of the enterprise residences, offices and manufacturing facilities are being managed utilizing smart tools, and the industrial sector's transformation trajectory is progressive. The demand for smart products is surging, calling for new and ingenious manufacturing approaches, and numerous producers have actually stepped up to the next level of industrial transformation. Recognizing the nature of the change in the production sector will certainly aid to establish which methods are likely to prosper and which will not.

At the end of the eighteenth century, manufacturing industries steered away from the artisanal approach and moved toward machine-assisted work, and when electrical power was utilized in manufacturing facilities, it led to real mass production becoming a viable choice. Possibly, one of the most impactful changes has been the transition to automation. The introduction of computers in production became more and more noticeable, with digital systems being developed to oversee a whole assembly line. Presently, customers want things faster and also better, customized and distinct. Consequently, manufacturers have to not only find a method to maintain the demand for products but also find skilled workers to make these products.

The advancements in technology and the consequent growth of the industry have improved the status of the business and gained the trust of its customers. Scientific research and development along with computer simulation in product advancement as well as other locations have made a significant influence. Every new advancement has brought a change in the production process that has in fact transformed the way the industries function across different sectors. Generally, the growth of industrial transformation shows the complete understanding of how technological innovation improves the growth of manufacturing industry. The application of industrial robots along with artificial intelligence is on the rise and they are much more sophisticated and proficient at doing intricate jobs. Even the expense differential with human beings is narrowing, to the advantage of robotics.

Transformation from analogue, mechanical, along with digital innovation, describes the path to digital innovative technology. Bridging the gap between design and manufacturing through services and making use of big data, data analytics and

machine learning transform to the fourth industrial revolution. Understanding the importance of data generated across the manufacturing enterprise opens up opportunities for the evolution of new business models that transition from being product centric to customer-focused service centric.

## FUTURE INDUSTRIAL TRANSFORMATION

A great deal of the innovations that are in practice currently are facelifts of the fundamental ideas laid throughout the transformations that took place so far. The fifth industrial transformation, also known as Industry 5.0, is already becoming part of the industrial automation landscape. Industry 5.0 combines human creativity and workmanship with the rate, effectiveness and also consistency of robots. Moreover, it complements human beings by whetting their creative thinking. Industry 5.0 creates even higher-value tasks than Industry 4.0, due to the fact that human beings are reclaiming product design through manufacturing that calls for creativity.

Robot guides, group control directed by artificial intelligence and also immersive virtual reality are among the technologies, allowed by the internet of things, set to delight fans at Tokyo's 2020 Olympics. Robots (Field Support Robot, Remote Location Communication Robot, Human Support Robot, Delivery Support Robot) established by the Toyota Motor corporation will certainly help spectators in a series of tasks, from carrying food and also various other items to showing people to their seats and also supplying information on occasions. The robotics also help functional real-life implementation aiding individuals, besides visitors in mobility devices.

*(Olympics, 2019; Forbes, 2019)*

To strike a balance wherein the machine-human interaction can supply the highest possible benefits, where increasingly complex processes will certainly call for an ecosystem that is capable of handling the substantial amount of information generated and also provide human operators with a room that they can utilize to connect with shop floor machines with the development of digital twins. Industry 5.0 combines human creativity and robotic accuracy to engender a distinct option that will soon be in demand of the coming years. Both Industry 4.0 and Industry 5.0 have paved a road map that industries can/shall follow in order to sustain.

## SUMMARY

Technology-driven transformation requires the appropriate organization culture and management executives to function appropriately. Modern technology alone is not enough to drive these transformations; business leaders need to engage with their workers to encourage understanding and adoption. Manufacturing industries that takes care of to foster the appropriate culture to incorporate these new technologies will be the ones with a competitive advantage, improving their existing business models, developing new possibilities, all the while retaining time-tested skills and simultaneously drawing in brand-new skills. Strategic investments continue to be vital for every manufacturing organization's ongoing development; even if different aggregating techniques in varied operations can be made complex, the process can

aid manufacturers to see high returns in the increasingly competitive environment. This is really a future that provides value to the manufacturing. A key aspect in improving business performance is having the most efficient processes and the most effective people, focusing on a client's outcomes and using cutting-edge technology to identify areas for improvement to leverage engineering process effectiveness through manufacturing effectiveness across the different levels of the enterprises.

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